Many Are the Values of the Apple

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Of our 120 million bushels of apples a year, 65 million go into retail channels; 10 into vinegar; 8 into sauce; 5 each into canned slices, evaporated slices, and export; 4 into cider for roadside stands; 4 into apple juice, and 2 each into frozen slices and apple butter. Ten million bushels are used in a few other ways or are left in the orchard. No other American fruit can approach that combination of volume and diversity.

In the United States, apples are grown primarily for sale as fresh fruit. Our leading commercial varieties are Red Delicious, Winesap, McIntosh, and Jonathan, noted for their attractive appearance, aroma, and good eating quality. Two others, Rome Beauty and York Imperial, are used extensively in cooked products.

The demand for fresh apples is fairly constant. In a normal year it amounts to about 55 percent of the crop. Only Fancy grades (large, well colored, and free of defects) can be sold profitably as fresh fruit. The proportion of fruit that will grade Fancy depends on weather, effectiveness of spraying, cultural practices, and care in picking and handling. Even under the best conditions, 10 percent or more of the crop will be culls; sometimes the proportion may be as high as 50 percent.

Dr. A. E. Murneek, of the Missouri Agricultural Experiment Station, gives lack of size and color as the principal reason for grading apples as culls. Although less attractive, cull apples have approximately the same flavor, composition, and nutritive value as Fancy market fruit.

Something must be done with the culls. Here is where the processing plants come into the picture. Today they play an integral part in the orderly marketing of the crop, at the same time providing a great variety of food items and at least two industrial products.

APPLE FLESH contains about 84 percent water and 16 percent solids. Three readily assimilated sugars constitute more than 80 percent of the carbohydrates. They are: Levulose, 60 percent; glucose, 25 percent; and sucrose, 15 percent. The levulose enhances the sweetness. The acid present is almost entirely malic acid. Green apples may contain a small quantity of starch, but mature fruit contains only a trace. Besides small amounts of protein, fat, and fiber, apples contai ascorbic acid and traces of vitamin thiamine, and other B vitamins. Apple flesh and, especially, peel are high in pectin. That is why dried apple wastes are an important source of pectin for the jelly and preserve industry.

WHEN APPLES GO TO THE FACTORY they may be converted into any one of 17 primary products. Two potential products, wax and malic acid, are not yet produced on a commercial scale.

Products from apple flesh are prepared from the Utility grade—ripe fruit that is relatively free of defects and 2¼ inches or larger in diameter. Because the first step is peeling and coring, size is important in reducing waste and in raising the output per machine. For example, 100 pounds of 2¼-inch apples will yield only 53 pounds of slices, but the same weight of 3-inch

apples will yield 78 pounds of finished product. The difference in output by machine or man-hour is even greater in favor of the larger fruit.

A sizable apple-slicing industry has developed near some large cities to supply bakeries with fresh slices for pies. The amount thus used probably exceeds 2 million bushels a year. Many large orchards, particularly in the East, have installed peeling and slicing equipment in connection with their packing and cold-storage facilities. The usual procedure is to pack the Fancy grades, place the Utility-grade culls in cold storage, and dispose of the smaller culls for juice or vinegar. With a proper choice of varieties and adequate storage, the grower can supply a bakery with fresh slices daily the year around.

Apple tissue contains a catechol-tannin pigment and oxidative enzymes, which cause the slices to turn brown when they are exposed to the air. Dipping the slices in a salt brine of 1 or 2 percent delays browning for several hours. The addition of small amounts of sulfur dioxide or of sulfites to the brine extends the effective holding period to several days. Fresh apple ices so treated have been sold at retail in 1-pound packages in New England.

Many of the summer and early fall varieties, and even the firmer-textured winter varieties, tend to become mushy when baked into pies. The soft slices may be firmed by dipping in dilute solutions of calcium chloride, and it is possible therefore to use many apples that used to be considered too soft for baking.

Canning apples has been a sizable industry for three decades or longer. The principal canning areas are New York, Pennsylvania, Virginia, and Washington. About 5 million bushels a year are so used. Most plants can three or four varieties selected for flavor, color, and texture. Apple slices to be canned usually are blanched to soften them, to destroy oxidative enzymes, and to expel air from the tissues so as to reduce corrosion of the cans. Canned apples are easily sterilized because of their acidity. If the blanched slices go into the containers hot (175° to 180° F.), very little additional heating is required. Most canned apples end up in pies or sauce. Calcium salts also are used now to firm canned slices. Another development is the canning of baked apples, a process suggested by workers at the Massachusetts Agricultural Experiment Station. At least one company has put on the market a retail-size jar of apple pie filler ready for the crust.

Frozen apples are relatively new, but they are going strong. Prevention of discoloration, particularly the internal browning on thawing, is the chief technical difficulty in preparing frozen apple slices. Several procedures have been developed. Steam blanching is rather effective, but it softens the tissues and leaches out part of the soluble sugars. Another method is to dip the slices in a solution containing 0.2 to 0.3 percent of sulfur dioxide or an equivalent concentration of various sulfite salts. Other methods remove air from the slices by applying a vacuum and subsequently filling the air spaces with a salt or sugar solution. More recent is the use of ascorbic acid to prevent discoloration.

Applesauce is a smooth and nearly colorless, slightly sweetened product from apple pulp. To comply with Department of Agriculture grade specifications, sauce must be prepared from peeled and cored fruit. It can be made more cheaply from whole fruit, but the product is darker and contains more defects (peel and calyx particles). Texture is important. A granular, rather than a pasty, texture is desired. Commercial sauce is commonly packed in No. 2 cans for the retail market or No. 10 cans for institutions. Some frozen applesauce is put up in 1-pound cartons.

Dehydrated apples appear on the market as slices, rings, or cubes. The demand for dried slices has fallen off in recent years, partly because of the increased production of frozen slices. The tan-colored, sun-dried slices commonly prepared on the farm are just about out of date commercially. In the

factory, apples are always exposed to the fumes of burning sulfur before drying, in order to bleach the surface of the fruit and to prevent further browning. The sulfured pieces are usually dried in kilns or on trays under controlled conditions of temperature, humidity, and air flow. Dried apples are graded on texture and appearance, rather than flavor. Varieties that are firm and yield a white product are preferred. Most of the dehydration plants are in California and Washington. The preferred varieties for drying are Newtown Pippin, Spitzenberg, and Gravenstein.

Apple nuggets are crisp, popcorn-like granules of low moisture content. Dehydrated apples (24 percent moisture) are cut into ¼-inch cubes and dried to less than 2 percent moisture in two stages, the second of which requires a vacuum drier. The product is highly concentrated. It contains nearly 70 percent of sugars and must be packed in moistureproof cartons. One pound of nuggets, with added water and sugar, will make 9 pounds of applesauce. This found a place in Army cookery. The boys probably complained about this applesauce, but then proceeded to enjoy it.

Chops are another common form of commercially dried apples. For them, small culls can be used, because peeling and coring are not required. The whole apple is sliced horizontally into discs about an eighth of an inch thick and dried without sulfuring. Chops are used in apple butter.

Apple powder, prepared by spray drying a slurry of peeled fruit, is another dehydrated product, but its demand is limited to medicinal use. It has been approved by the American Medical Association for the treatment of certain types of diarrhea.

Cider and hallowe'en have belonged together for generations. Because cider is the freshly pressed juice, not pasteurized, it does not keep very long and can be produced only while fresh or storage apples are available. It is such a refreshing drink, however, that as soon as flash pasteurization of juices was developed, about 1937, cider was put up in cans or bottles for year-around consumption. The product is usually called apple juice, although no official distinction is made between the words. The peak of consumption comes in October, but we now drink apple juice the whole year. Although cider and apple juice together amount to some 25 million gallons a year, that is only about one-sixth of a gallon a person—the Swiss drink 2 gallons. We predict a steady increase in the use of apple juice. It is an excellent way to use up surplus apples. When it is made from a good blend of ripe fruit, it is a delight to the palate.

The ascorbic acid in raw apples is almost completely lost during processing. Addition of the vitamin to juice became widespread in this country during the Second World War. For several years it was compulsory in Canada, because it was a way to provide vitamin C in the absence of an adequate supply of citrus fruits. Ascorbic acid, an antioxidant, also helps maintain flavor during storage.

A new type of product, called liquid apple, is apple juice plus finely pulverized pulp in stable suspension.

Frozen apple juice in retail-size containers has been popular in California. A frozen juice concentrate similar to frozen orange concentrate is now being developed.

Several agricultural experiment stations have undertaken the study of blends of apple and other fruit juices—apple and cranberry blends in Massachusetts; apple and various small fruits at the station in Geneva, N. Y.; and grape-apple blends at the Ohio station. Apple-lime blends were favorably received in commercial trials in Canada. The next few years will determine whether these specialty items have sufficient merit to create a large demand.

APPLE ESSENCE is the volatile fraction of the fruit. These volatiles are a complex mixture of acids, esters, alcohols, and aldehydes.

J. W. White, Jr., of the Eastern Regional Research Laboratory, who studied the composition of the mixture, identified 26 different compounds. The total amount of the substances in fresh apple juice is about 50 parts to the million. They evaporate so easily that they are completely lost in the preparation of sirup, concentrate, and evaporated slices, and are lost to some extent in pasteurized juice, canned apples, and sauce.

The process of recovering the volatiles in concentrated form, which was developed by H. P. Milleville and R. K. Eskew of the Eastern Laboratory, consists of three steps: Rapid vaporization (in 15 seconds or less) of 10 percent of the fresh juice; separation of the vapors from the liquid; and fractionation of the vapors to obtain a one-hundred-fold to one hundred and fifty-fold concentration. One gallon of one hundred and sixty-fold essence would contain all the volatile flavors from a ton of apples. The essence can be prepared economically from juice that is intended for sirup or concentrate, because the volatiles would be lost anyhow during vacuum evaporation. When a small amount of the essence is added to apple concentrate of a good grade and reconstituted with water, the product is indistinguishable from fresh apple juice. As might be expected, the character of the essence varies with the variety of apple from which it is produced. In general, the more aromatic varieties, such as McIntosh and Red Delicious, produce stronger, more aromatic essences.

Products improved by the addition of apple essence include jelly, candy, sauce, and sirup. Apple concentrate fortified with essence could be used as a fountain sirup. Several carbonated soft drinks are flavored with apple essence. It has also been suggested as a flavoring for pharmaceuticals like cough sirups and tooth paste.

Several sirups and concentrates are made from apple juice. If the juice is boiled down in an open vessel, the product is called boiled cider; it is rather dark and has a strong taste. If it is evaporated under vacuum, the product is called concentrated apple juice, or merely apple concentrate; it is lighter in color and milder in flavor, although still sharply acid. If the acidity of the juice is removed or neutralized and the juice evaporated under vacuum, one of several types of apple sirup is produced.

The pectin in apple juice is sufficient to cause gelation if the juice is concentrated beyond 55 or 60 percent of soluble solids. A depectinized juice may be concentrated to 68 or 70 percent of soluble solids without gelation; that is the usual product of commerce. Its sugar content is enough to make it self-preserving. Apple concentrate is used chiefly in jellies and apple butter.

Apple juice may also be concentrated by freezing out the water. Such concentrates contain all the volatile aroma present in the original juice because the juice has not been heated, or subjected to a high vacuum.

APPLE SIRUP, developed at the Eastern Laboratory in 1942, is light amber, bland, and slightly sweeter than honey. Because of its high levulose content, it was used during the war as a substitute for glycerin in conditioning tobacco. The estimated 10 million pounds of sirup produced in this country and Canada between 1943 and 1947 utilized nearly 1.5 million bushels of cull apples.

The original process, using lime to neutralize the acidity and remove pectin, gave a product having a slightly bitter taste of calcium malate. A better flavored sirup, suitable for table use, may be prepared by removing the acid on a bed of ion-exchange resin. Malic acid would be a byproduct of this process, once it is put into commercial operation. Apple sirup cannot compete with corn sirup on a cost basis, but there may be a market for blends of apple and corn sirups or blends of apple and low-grade maple sirups, which have an excess of maple flavor.

Studies by C. C. Flora and C. W.

Holdaway at the Virginia Agricultural Experiment Station have shown the value of apple sirup for reducing curd tension of milk products for infant feeding

OF THE FERMENTED PRODUCTS from apples, the most important is cider vinegar. It is prepared by the fermentation of sugars to alcohol by yeasts, followed by oxidation of the alcohol to acetic acid by acetobacter, commonly called mother of vinegar. An apple juice that contains more than 9 percent of sugars should produce a vinegar containing more than the legal minimum of 4 percent acetic acid. The wild yeasts present in all fruit juices usually produce an inefficient fermentation. It is more efficient to add pure yeast cultures for the first fermentation and to use vinegar generators with controlled temperatures and air-flow rates for the second stage.

Several alcoholic beverages can be prepared from apple juice. The term "hard cider" often signifies a partly fermented apple juice that contains 4 to 6 percent of alcohol and several percent of residual sugar. Apple wine is prepared by adding pure wine yeast to a mixture of apple juice and sugar. Apple brandy is a distilled beverage. These products are prepared in relatively small amounts and utilize only a small quantity of cull fruit.

EVEN THE PEELS AND CORES of apples are used. In the manufacture of nearly all apple products, except apple butter, a large proportion (30 percent or more) of the apple is left as peels and cores or pomace. The peels and cores can be further ground and pressed to yield pomace and juice, which is suitable for sirup, concentrate, or vinegar stock. In an average year, the total volume of processing residues exceeds 200,000 tons.

The most profitable use for dried apple pomace is to make pectin for jams, jellies, and preserves. Many jelly manufacturers buy dried apple pomace and make their own pectin concentrate as needed. Others buy pectin as a liquid concentrate or as a dry powder.

Another type of pectin, called low-ester pectin, has been developed. Unlike ordinary pectin, it does not require a high sugar concentration to produce gelation, but will form a gel in the presence of a small concentration of calcium. With this modified pectin, jellied fruit desserts and aspics can be made with a small proportion of sugar, or none at all. Jellies made with 35 to 45 percent of sugar have more of the natural fruit flavor than those made with the customary 55 percent. During the war, the Army used nearly 20 million 4-ounce cans of jellied fruit cocktail made with low-ester pectin.

BESIDES their many food uses, pectin or pectin derivatives may serve as thickening agents in pharmaceutical preparations, in pastes and salves, and as an agar substitute in preparing bacteriological culture media. Nicotine pectate has been suggested as an insecticide. Crude pectate solutions have been used in baths for quenching steel. Chemists at the Western Laboratory have developed pectinate films, which provide nonsticky, edible coatings for frankfurters, dried fruits, and candy.

Because of the limited demand for pectin and the serious competition from citrus pectins, probably less than half of the available apple-processing wastes are used in manufacturing pectin. Fresh apple pomace, or marc, contains about 30 percent solids and is rich in digestible carbohydrates.

F. B. Morrison, the well-known authority on animal feeding, wrote that apple pomace is "a good substitute for corn silage in feeding dairy cows, being approximately equal to corn silage in value per ton." In areas near processing plants it is customary to feed fresh or ensiled pomace. Dried pomace is relatively nonperishable and may be stored for years. It is usually fed with molasses or other concentrates.

Several hundred tons of dried apple pomace is used annually as a carrier for insect bait. It attracts grasshoppers

nd other insects and may be used in lace of wheat bran. Dried pomace ontains nearly 1 percent of peel wax, and the seeds contain more than 30 percent of oil. The total quantities of these materials would be too small to justify their recovery unless they were found to have special useful properties.

SECONDARY APPLE PRODUCTS are those prepared from one or more of the primary products we have described. They include apple jelly, candy, pie, mincemeat, and dozens of home dishes made with apples.

Apple pie, the great American dessert, is the end product of some 10 million bushels. Most of the commercially prepared canned, frozen, and fresh apple slices reach the consumer between crusts. The restaurant trade requires firm slices, which make its pies attractive in cross section. Only the firmer varieties of apples were formerly used for commercial pies, but many of the summer and early fall varieties, which have excellent flavor, may be treated with calcium salts to provide firmness.

Apple and apple-base jellies contain two apple products, pectin and concentrate. According to Federal regulations, apple jelly must contain 45 percent of apple juice or an equivalent amount of concentrate, plus added sugar to give a final concentration of 65 percent soluble solids. Apple-base jellies usually are blends of apple and some other fruit juice, such as grape, cherry, blackberry, or raspberry.

APPLE BUTTER is prepared from fresh fruit, barreled pulp, or dried chops. As a rule, boiled cider or concentrate is added and the entire mass heated for several hours in an open kettle. Concentration of the pulp under vacuum would yield a lighter product, but the deep-brown color of apple butter has been one of its distinguishing characteristics since pioneer days. After the desired consistency and color have been reached, sugar and spices are added, and the pulp is passed through a finisher that has one or more fine screens, which remove particles of peel, seeds, and stems.

Other commercial items that contain apple products are mincemeat, full-flavored apple concentrate, and various soft drinks fortified with apple essence. An apple ice, containing small bits of ground apple slices and flavored with apple essence, has been prepared on a pilot-plant scale but is not yet a commercial reality. A series of fruit products called Velva Fruit, containing a high proportion of ground fruit plus suitable amounts of sugar and gelatin for stabilizing, has been developed at the Western Laboratory.

IN THE HOME, apples are used in quantities beyond our ability to estimate—for baking, boiling, frying; in pie, dumplings, brown betties; in salads, cakes, pinwheels, and pandowdy. The New York and New England Apple Institute, 43 Crown Street, Kingston, N. Y., compiled a list of more than 200 recipes featuring apples.

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